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Progress in Canadian Oyster Hatchery Development

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A supply of seed oysters is the most pressing need of the oyster industry of the Maritime Provinces. Natural oyster production is extremely variable and steadily decreasing in the face of the deleterious changes in our bays and estuaries brought about by man's activities. Attempts to utilize natural seed oyster production as efficiently as possible are continuing, but even at best the supply from this source is too small and too unreliable to support a healthy industry.

The concept of utilizing the tremendous reproductive potential of the oyster to produce large quantities of seed under controlled conditions is not a new one. Much of the basic information required to make this a reality has been available for some years, but little practical progress has been made in converting this knowledge into a reliable industrial process. Using this knowledge as a springboard, rearing of oyster larvae at Ellerslie began on a laboratory scale in 1959. The results were sufficiently encouraging to justify the building of facilities to test the technique on a commercial scale.

Working with the basic concepts provided by Fisheries Research Board of Canada scientists, the Fish Culture Development Branch engineers designed, and had constructed in 1963, the Experimental Oyster Hatchery at Ellerslie, Prince Edward Island. It was officially opened by the Minister of Fisheries in 1964 and has operated from the beginning under Board supervision with staff from both the Department and the Board.

Aims

The aims of the Experimental Oyster Hatchery program are twofold.

The first is to develop reliable techniques of rearing seed oysters on a commercial scale. When this is accomplished, it is expected that private commercial oyster hatcheries will evolve to fulfil the seed requirements of oyster farmers. The experimental hatchery would have a continuing role to play in further development and refinement of techniques, training of personnel, providing technical advice, and carrying out some of the technically more difficult operations as a service to industry. The details of this relationship can only be determined when the techniques and their relative cost and technical difficulty are determined.

The second is to select stocks of oysters with desirable characteristics, such as fast growth and disease resistance. It is known that there are differences in resistance to disease between natural stocks of oysters and there is evidence that such stocks differ in other ways also. The feasibility of using such selected stocks will depend on the availability of a method of breeding them in sufficient quantities to supply industry. Breeding from selected fast-growing oysters has already begun in the hatchery as the first step towards developing a strain which will grow faster than those now available.

Hatchery Layout and Staff

Oysters reproduce by releasing eggs and sperms. One female may emit in excess of 20 million microscopic eggs. The fertilized eggs develop into free swimming larvae which subsequently settle and metamorphose into small oysters known as spat.

The hatchery is designed to provide facilities for the steps involved in producing oyster spat for growth outside. These steps are: conditioning of the gonads, spawning, larval rearing, spat settlement, and spat rearing.

The hatchery was designed to provide separate areas for these steps and for ancillary facilities for food culture for the spat and larvae. The mechanical equipment, including pumps, temperature control equipment, sea water filters, and clarifier, is contained in a room at one end of the building. Processed water is then piped to the appropriate areas elsewhere in the building. In addition, the hatchery contains an office for records and a small laboratory.

Experience at Ellerslie has shown that a staff of four technicians will be required for the operation of the oyster hatchery. In addition to this, it has been necessary to utilize casual labour for short periods. It is likely, with suitable automation of the larval rearing operation, that a large commercial oyster hatchery would operate with the same staff.

Water Supply

Water is drawn continuously from the estuary through a polyethylene pipe by self-priming pumps. The system is designed to cope with two natural hazards, damage by storms and winter ice and internal fouling of the intakes by marine organisms. The fouling organisms cut down water flow and also act as a very efficient filter, removing the natural food of the oyster larva.

There are actually three intakes, one for use during the winter periods, when there is no marine fouling, and two smaller summer lines. In the winter line, the polyethylene pipe is placed inside an asbestos-cement pipe which doubles as a drain for waste water. This arrangement is very satisfactory as it permits changing the intake line simply by withdrawing it and inserting a new line from inside the hatchery. Two people can replace 250 feet of line in about half an hour. The line runs underground from the building to below low water level and continues underwater below the level reached by winter ice which averages 3 feet in thickness at Ellerslie. The summer lines are similarly arranged except that they are inside large polyethylene pipes which do not serve as drains. These lines are shorter and of smaller diameter and are used alternately during the summer period when marine fouling occurs. The intake end of the line not in use is raised above the surface and the line is filled with fresh water to kill any accumulated fouling organisms. These dead organisms are flushed out before the line is placed back in service.

The accumulation of silt and fouling in the intakes is an important factor in the hatchery process. Therefore, the intake lines are the minimum length necessary to obtain a suitable water supply.

Water Clarification

It is essential that all water entering the hatchery system be clarified. Animals which would settle in the hatchery and compete with oysters for food, and silt which would foul the system and interfere with oyster raising must be removed. In addition, the efficiency of water sterilization by ultra-violet light, a later step in water treatment, is greatly increased by efficient clarification of the sea water. At the same time, the small plants used as food by oyster larvae and spat should not be removed.

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Initially this clarification was accomplished by passing the water through cartridge-type filters. Later, upon the completion of laboratory testing, a large, centrifugal clarifier was installed. Both of these devices are satisfactory, but each has certain disadvantages. The filters provide water of suitable quality without removing the useful food organisms, but, when there is a heavy silt load, the cartridges must be changed frequently, with resultant increased operating costs. The centrifugal clarifier is extremely efficient with respect to providing clean sea water. To avoid removing all useful food organisms, the machine must be operated above its rated capacity. The main disadvantages of this equipment are: that it is too costly for a commercial hatchery to install and operate, that it must be operated at a fixed, highflow rate, and that the stainless steel in the bowl is subject to electrolytic corrosion. Metallic ions thus released have adverse effects on the oyster eggs and larvae.

Other methods of water clarification, including the use of sand filters, are being considered and tested.

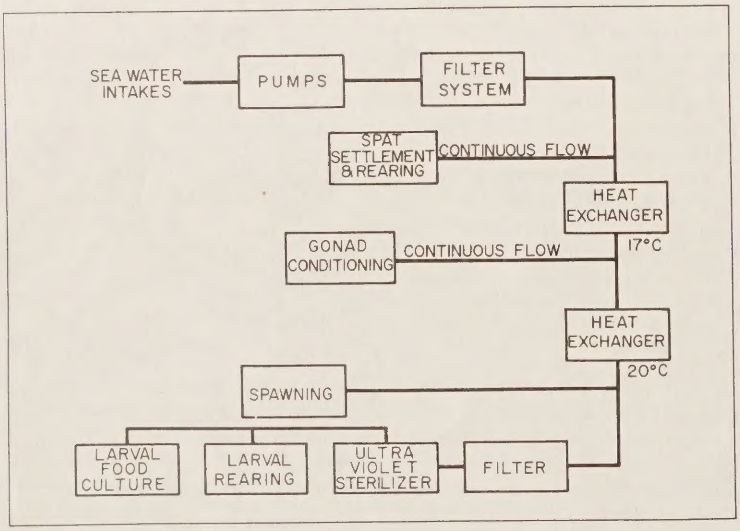
Conditioning of Parent Stocks for Spawning

In natural conditions oysters develop ripe gonads in early summer and spawn when water temperatures reach suitable levels. In the hatchery, spawning must be controlled to supply fertilized eggs as required. This is readily achieved by holding the adults in sea water at a temperature of 18°C (64°F) for the conditioning process. At this temperature the gonads ripen in 3 – 4 weeks after which spawning can be delayed for up to two months.

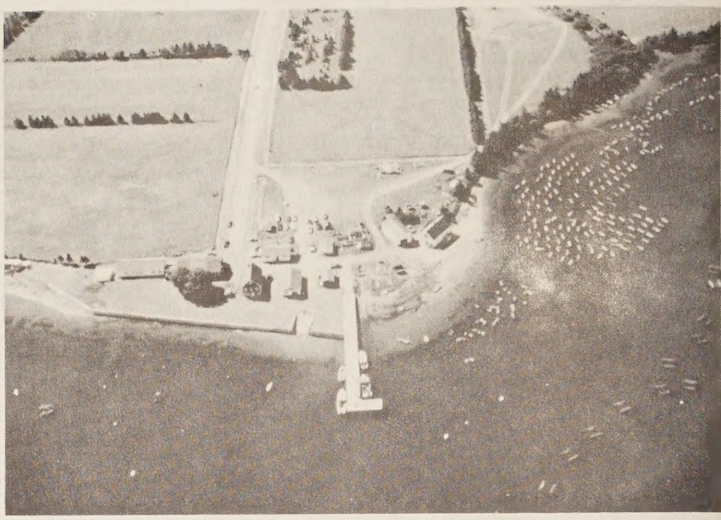
At Ellerslie the sea water for conditioning is controlled to a temperature of 18° C by warming or cooling it, depending on the season, by passing it through a heat exchanger. Heat is supplied from a hot water boiler which also serves as a heating unit for the building. Cool well water is used to lower the sea water temperature. A pneumatic temperature control system is used because of the fine degree of temperature modulation possible. A major problem developed when electrolytic corrosion of the stainless steel tubes in the heat exchangers released metallic ions to the sea water in the same way as with the centrifugal clarifier. Means of overcoming these corrosion problems are being investigated.

The oysters are conditioned for spawning in fibreglass trays so stacked that water introduced at the top runs down from tray to tray and finally to the drain. This is a convenient and compact unit which makes it possible to inspect any desired tray of oysters without disturbing the others.

Experience now indicates that a smaller continuous flow of water may be used in this step. This water would be stored in large fibreglass reinforced plastic (FRP) tanks. The stainless-steel heat exchanger would be eliminated and the water temperature controlled by passing hot or cold water as required through coils built into the tank, or by the use of inert immersion type heat exchangers. The heat-sink effect of this quantity of water would give extremely uniform temperatures. The water would then be circulated through the trays of oysters, or the trays could be supported directly in the tank. This revision in the conditioning process is being tested at Ellerslie.



Schematic showing water treatment and distribution in the Hatchery.



Spawning

To stimulate spawning, ripe oysters from the conditioning trays are placed in clean sea water and the temperature is raised to 25–30°C (77–86°F). Oysters which spawn are removed to containers of clean sea water. Eggs released are washed through a fine screen, sperm added and the fertilized eggs put into rearing containers. If oysters are fully ripe, the whole spawning process is a rapid and simple one. Within twenty-four hours the fertilized eggs develop into swimming larvae.

Larval Rearing

The larval stage is the most vulnerable phase of the oyster's life, and this step is the most difficult in the hatchery process. Water quality is of supreme importance here.

Larvae are reared in conical FRP tanks each containing 100 gallons of sea water and 3 – 5 million larvae. Clarified sea water at 20°C is supplied to the tanks via an ultra-violet sterilizer where bacteria in the water are killed. Control of bacteria in larval cultures is essential to successful larval culture. The initial installation used a fixed sterilizer from which sterilized sea water was distributed to the rearing tanks. This system involves the danger of recontamination of the sea water by bacteria which multiply in the distribution system. It is important that this distribution system be as short as possible and be cleaned out regularly. Two alternative techniques are being tested, sterilization of the water directly in the tank and a mobile sterilization unit which delivers sterile water directly to the rearing tanks.

Antibiotics have been widely used to control bacteria in rearing larvae. In early trials at Ellerslie, they were used routinely. Bacteria are now controlled by regular water changes and in-plant hygiene with the antibiotics held in reserve for emergencies.

Oyster larvae are held in the rearing tanks until they reach setting size. This usually takes 19 – 21 days at a temperature of 20°C (68°F). During this time the water is changed daily. The contents of the tanks are run off through a nylon screen of a suitable size to retain the larvae, which are washed thoroughly and returned to the tank, which has been cleaned and refilled with new sterilized sea water.

Experience at Ellerslie in the past six years has shown that the local waters are normally sufficiently rich in natural food during the open water period to sustain larval growth. Supplementary cultured foods must be added only during the winter or unusually poor years.

The history of larval rearing in the hatchery has been a mixed one. In earlier laboratory studies no difficulties had been encountered providing larvae were given sufficient food. After an initial successful rearing, early attempts in the experimental hatchery failed completely. Eggs often failed to develop properly and larvae did not grow. These results were eventually traced to toxic materials released by electrolytic corrosion of stainless steel in the heat exchangers. Sacrificial, magnesium-zinc electrodes connected to all stainless

steel equipment immersed in sea water running to waste removed the biological effects, though some corrosion still takes place.

In general, since this corrosion was reduced, larval rearing has been very successful, with the larvae growing and surviving well. Low growth rates and high mortalities did occur in some larval batches in the summer of 1965. These were traced to either poor feeding conditions due to fouling of the intake lines or high bacterial counts in the rearing tanks from dirty distribution lines. Improved maintenance and strict sanitation removed the sources of these difficulties. The larval rearing step, though basically quite simple, consumes the largest portion of the staff's time. For this reason, it is the step which should receive the closest attention with respect to automating the oyster hatchery operation.

Spat Setting

When larvae reach setting size, they are screened out on a nylon mesh of appropriate size and transferred to tanks provided with suitable collector materials.

The requirements of a collector material are complex. A suitable collector must be non-toxic and attractive to oyster larvae. It must be compact enough to allow sufficient water circulation to achieve good growth. It must be robust enough to withstand handling but also allow the separation of individual oysters when these have grown large enough. A number of materials have been tested. The one currently showing the most promise is a wood-veneer ring coated with a sand-cement mixture, then leached for a week in sea water to remove toxic elements. Another which shows great promise is a polyvinyl-chloride mesh which is now in commercial use in France. The mesh is coated with a sand-lime mixture and has the advantage that, after removal of the oysters, the basic material can be re-used.

Originally, setting was carried out in large polyethylene tanks in which coated, veneer rings were stacked. This system had several disadvantages. Larvae set readily on the walls and sides of the tank and unevenly on the collectors, setting more densely on those at the bottom of the tank and preferring horizontal surfaces to vertical ones. Shallower tanks containing only one layer, of collectors and lined with FRP are now under test.

Growth of Spat

In the original concept of the operation of the hatchery, it was planned that spat would be put out into natural conditions immediately after setting. It was found in the early trials of 1964 that such small spat were very susceptible to silting and fouling, which caused high mortalities. It was obvious that spat would have to be protected from such dangers until they were large enough to survive them. Accordingly, in 1965 spat were kept in the hatchery for 3 – 4 weeks after setting, and fed on cultured food before being put out in natural conditions. This has produced most encouraging results. The first rearing of oysters treated in this way has reached, at the end of six months, a size equivalent to two years' normal growth in nature.

Oysters are held in warm sea water (17-18°C) for three to four weeks to induce ripening of gonads.

Spawning is triggered by raising the sea water temperature.

The oysters leave the hatchery as spat 1/8 – 1/4" in diameter fixed to the collectors, which are then suspended from floats in the estuary where growth continues under natural conditions. They are held this way until they can be separated from the collector and placed on trays in a suitable nursery area, or until they are large enough for separation and direct planting.

Space limitations have restricted spat growth in the hatchery to laboratory-sized lots. A unit for the intensive growth of spat is being designed and will be built in the near future. This will lead to the development of techniques of commercial scale.

Feeding of Larvae and Spat

Originally, it was intended that cultured foods would only be used for larval rearing in the winter and for supplementary feeding in poor seasons. The provision of such food assumed greater importance when the necessity to hold settled spat in the hatchery for some weeks was demonstrated.

The classical method of culturing the small plants which oyster larvae and spat use as food is in large glass containers of sterilized, enriched sea water, carefully shielded from outside contamination. This is a complex, technical process and expensive on the scale required for commercial spat rearing. A much less complex system which shows great promise has been developed at Ellerslie.

Stock cultures are maintained by classical methods. Cultures used for feeding are held in FRP tanks illuminated by fluorescent lights housed in plexiglass tubes which pass through the tank from side to side. The culture is continuously circulated by a pump through jets which play on the bottom of the tank. This ensures even illumination, prevents the cells from settling out, and also allows circulation through a cooling bath if necessary. Up to half of the volume of the tank can be taken for feeding every day. The tank is replenished with filtered enriched sea water.

Cultures have been maintained for up to six months by this system. The spat which showed such good growth in 1965 were reared on cultured food in larval and early spat stages.

So far cultures have been harvested in bulk once daily. A continuous flow system, whereby a metered flow of sterile enriched sea water causes an overflow of culture directly into feeding tanks, is under development.

Even with the simplified system now used, the culture of plants for feeding is an undesirably costly practice in the hatchery. Some substitute food, preferably one which can be conveniently stored, would be extremely valuable. At Ellerslie, tests have been made using a number of vegetable leaves ground small

enough to be eaten by larvae and spat. While some of these have shown some promise, no satisfactory substitute for the cultured foods has yet been developed.

Commercial Hatchery Development

The work at Ellerslie has demonstrated the feasibility of the biological processes involved in hatchery production of seed oysters, as well as some of the engineering problems involved. Neither the economic feasibility of the process nor its reliability over a long period has been established. The present situation indicates that a successful commercial oyster hatchery could become a reality in the near future. It should be stressed, however, that this is still an undertaking which involves a substantial degree of risk. The process, which is in the early stages of development, has not yet reached the "add oysters and stir" stage.

It is also important to realize that Canadian experience is limited to one locality. Experience in other countries has shown that some techniques may only be successful in the area in which they are developed. Ellerslie was chosen as the site for the Experimental Hatchery for convenience and from the greater knowledge of this area, rather than from any belief that this is the most promising site in the Maritimes. Though the area has a number of favourable characteristics, there are also some serious disadvantages. Alternative sites might have characteristics which would allow simplification of hatchery processes or demand alterations.

With these reservations in mind, some general conclusions can be drawn from experience so far.

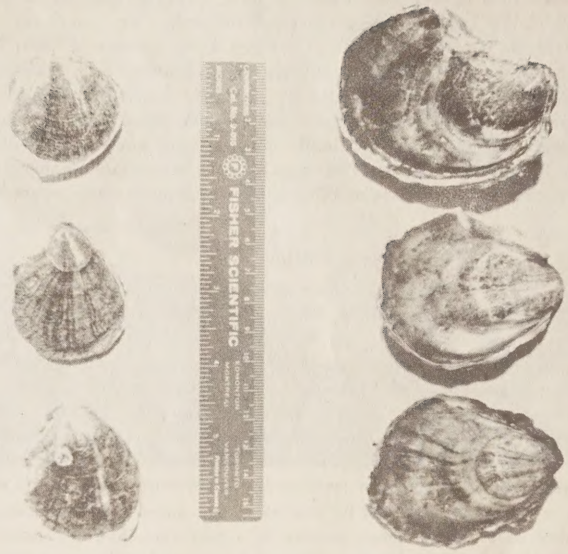
In Eastern Canada, the aim of a hatchery operation must be to produce single, good shaped oysters of bedding size ($1\frac{1}{2}$ – 2"). These must be held under controlled, inside conditions until 1/8 – 1/4", after which they may be grown outside.

The materials in contact with sea water in the hatchery operation should be chemically inert if possible. Glass, polyethylene, polyvinyl chloride, and FRP have been shown to be suitable. Metals should be avoided, particularly copper and its alloys. Even sea water resistant stainless steel should be kept to an absolute minimum.

Plant sanitation is extremely important. All incoming water must be filtered. The sea water distribution system should be kept as short and simple as possible, and so constructed that it can be quickly dismantled for cleaning.

At least one member of a hatchery staff must be trained in the necessary techniques and maintenance procedures. Some operations, e.g. food culture, require a good deal of technical ability, and all require care and attention to detail.

Although the present scheme has been shown to be feasible, it is unlikely to be the most economical or efficient which can be developed. There is a good deal of room for improvement in existing techniques or for the development of alternate ones. Some of these possibilities have already been mentioned, but there are others worth noting.



Growth stages in a commercial scale rearing in 1965, 6 and 18 months old.

Commercial scale operations have so far been limited to the spring and summer, when a reasonable growing period was left for spat. Techniques allowing year-round operation of at least the larval rearing process, could greatly increase production.

The present method of rearing spat in the early stages is a relatively costly one. A simpler process would be of obvious advantage. The use of covered tanks containing filtered, fertilized sea water show great promise.

These and many other possibilities are being explored and will be investigated. The results will almost certainly bring about radical changes in hatchery techniques in the next few years.

Growth stages in a commercial scale rearing in 1965, 11, 28, and 60 days old.